

**REMARKS**

**I. Introduction**

In response to the pending Office Action, Applicants have amended claim 12 in order to further clarify the subject matter of the present invention. Support for the amendment to claim 12 can be found, for example, in Fig. 3 and pages 3-4 of the specification. No new matter has been added.

For the reasons set forth below, Applicants respectfully submit that all pending claims are patentable over the cited prior art.

**II. The Rejection Of Claims 12-15 Under 35 U.S.C. § 103**

Claims 12-15 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Cadien (USP No. 6,375,552) in view of Maex et al. (US 2003/0162407). Applicants traverse this rejection for at least the following reasons:

With regard to the present invention, amended claim 12 recites a semiconductor device comprising a tungsten plug buried in a hole provided in an insulating film, a portion of the tungsten plug which is formed on a bottom surface of the hole includes crystal grains having a columnar structure, an average value of diameters of the crystal grains of a bottom portion of the columnar structure being 30 nm or less.

In other words, one feature of the present invention is that the crystal grains in the tungsten plug having a diameter of 30 nm or less may provide a tungsten film with excellent morphology to prevent defects such as seams in order to improve the reliability of the semiconductor.

In contrast to the present invention, both Cadien and Maex fail to teach or suggest a tungsten plug formed at the bottom surface of the hole that includes crystal grains having a columnar structure, or that the average diameter of the columnar structure is 30 nm or less.

Cadien teaches a semiconductor device comprising a tungsten layer with a diameter of 4500 Angstroms. However, Cadien does not disclose that the tungsten layer includes crystal grains. As such, Cadien is also silent with respect to the diameter of the crystal grains. Moreover, Maex fails to remedy this deficiency. Maex teaches a method of anisotropic plasma etching wherein the diameter of the openings is continuously decreasing in order to meet the high density integration requirements. Thus, Maex is also silent about the diameter of crystal grains. Accordingly, the allegation that a person having ordinary skill in the art would have been able to determine the diameter of the plug using routine experimentation is improper because the claim limitation is not directed to the diameter of the plug, but rather, the diameter of the crystal grains comprising a portion of the tungsten plug. As both Cadien and Maex are concerned only with the diameter of the plug, not the diameter of the crystal grains comprising the tungsten plug, the references, either alone or in combination, fail to teach or suggest the limitations of claim 12 of the present invention.

In order to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 180 USPQ 580 (CCPA1974). At a minimum, as Cadien and Maex both fail to teach or suggest a semiconductor device comprising a tungsten plug buried in a hole provided in an insulating film, a portion of the tungsten plug which is formed on a bottom surface of the hole includes crystal grains having a columnar structure, an average value of diameters of the crystal grains of a bottom portion of the columnar structure being 30 nm or less, it is submitted that Cadien and Maex, alone or in

combination, do not render claim 12 obvious. Accordingly, it is respectfully requested that the § 103 rejection of claim 12 be withdrawn.

**III. All Dependent Claims Are Allowable Because The Independent Claim From Which They Depend Is Allowable**

Under Federal Circuit guidelines, a dependent claim is nonobvious if the independent claim upon which it depends is allowable because all the limitations of the independent claim are contained in the dependent claims, *Hartness International Inc. v. Simplimatic Engineering Co.*, 819 F.2d at 1100, 1108 (Fed. Cir. 1987). Accordingly, as claim 12 is patentable for the reasons set forth above, it is respectfully submitted that all pending dependent claims are also in condition for allowance.

**IV. Conclusion**

Having fully responded to all matters raised in the Office Action, Applicants submit that all claims are in condition for allowance, an indication of which is respectfully solicited.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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